NF03 – Flavon exchange – a new model for neutrino oscillations

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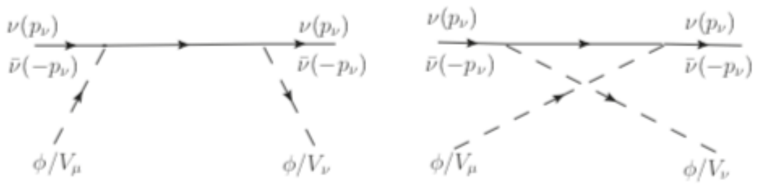
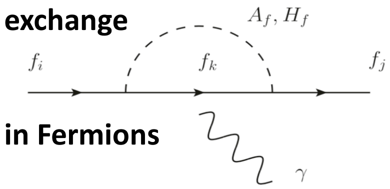
New model of neutrino oscillation

Flavon Model

Dark matter arXiv:1904.02518

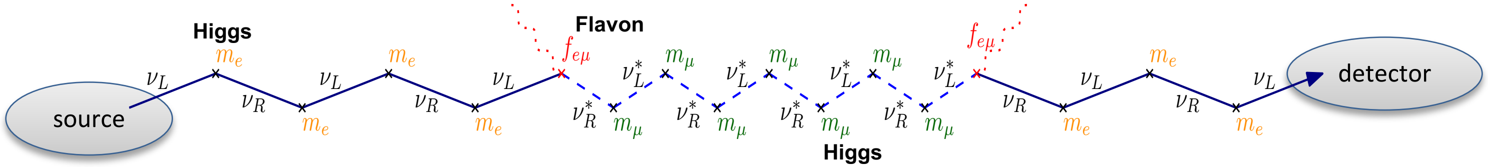


Flavon exchange in Fermions 10.1103/PhysRevD.81.036012



- Model (2002.12269) assumes that flavor change occurs at discrete external points.
  - Flavor change assumed as a small perturbation
  - Rotation of states is performed using a Pauli rotation trick

Simplified mass model – Murayama diagram



$$\langle \nu_l | H_0 | \nu_m \rangle = \delta_{lm} E_{\nu_m}$$
$$\langle \nu_l | H_1 | \nu_m \rangle = (1 - \delta_{lm}) f_{lm}$$

Proposed oscillation alternative (Flavon)

$$U(t) = e^{-i(f_{e\mu}\sigma_x + \Delta E \sigma_z)t/\hbar} e^{-i(E_{tot} I)t/\hbar} = U_{osc} U_{E_\nu}$$

PMNS *Constant amplitude. Maximum number of neutrinos that can be lost*

$$P_{ee} = | < \nu_e(t) | \nu_e > | = 1 - \sin^2(2\theta_{12}) \sin^2(\frac{\Delta m_{12}^2}{4E_\nu} t)$$

Amplitude not constant: Energy dependence. **Flavon**

$$P_{ee} = 1 - \frac{{f_{e\mu}}^2}{\left(\frac{\Delta m_{\nu_{\mu e}}^2}{4E_\nu}\right)^2 + {f_{e\mu}}^2} \sin^2\left(t\sqrt{\left(\frac{\Delta m_{\nu_{\mu e}}^2}{4E_\nu}\right)^2 + {f_{e\mu}}^2}\right)$$

Both formula consistent except at short and long period.
Flavon model: Long period ($P_{ee} \sim 1 - f_{e\mu}^2 t^2$) Short period ($P_{ee} \sim 1/E_\nu^2$)

*Formula untested but **consistent** with PNMS (**except** at short or long baselines)*

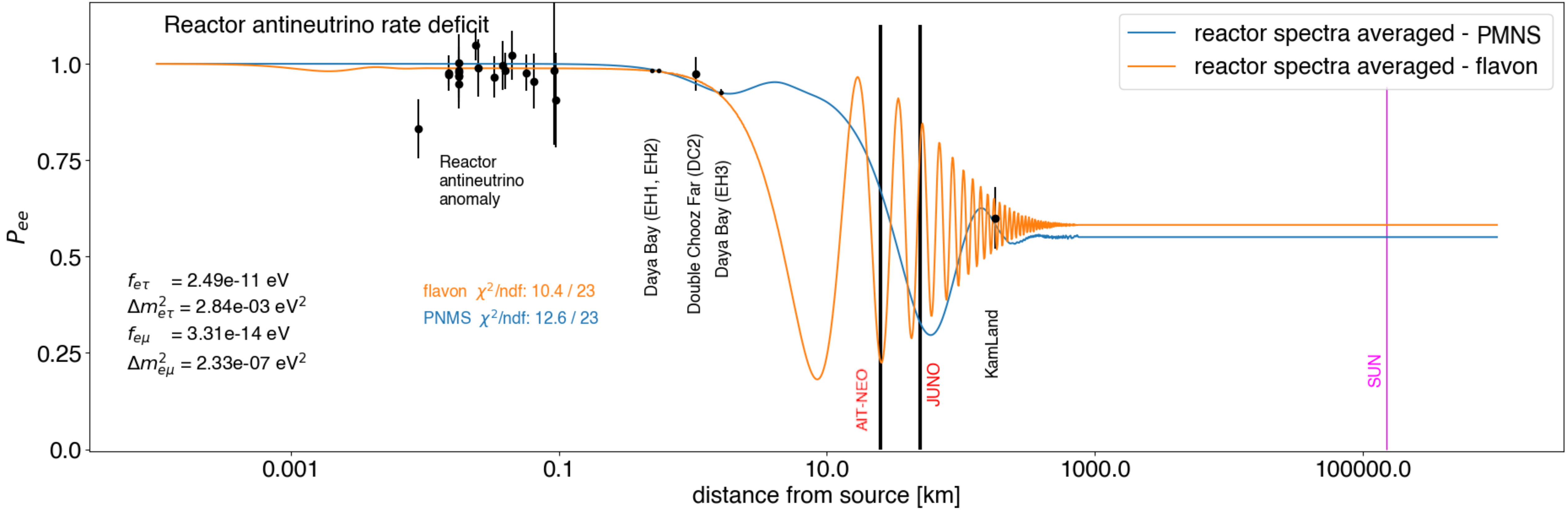
Reactor antineutrino rate picture

Flavon vs PNMS model

Perturbation

$f_{e\tau} = 2.49 \times 10^{-11}$ eV $f_{e\mu} = 3.31 \times 10^{-14}$ eV

$f_{e\tau} = 1.40 \times 10^{-10}$ eV $f_{e\mu} = 2.27 \times 10^{-13}$ eV $f_{\mu\tau} = 9.65 \times 10^{-12}$ eV



Provides agreement at short and long range.
Mid range experiments (AIT/JUNO) will be sensitive to this model.

New model of neutrino oscillation

Spectral agreement for Daya Bay and KamLand

Perturbation

$f_{e\tau} = 2.49 \times 10^{-11}$ eV $f_{e\mu} = 3.31 \times 10^{-14}$ eV

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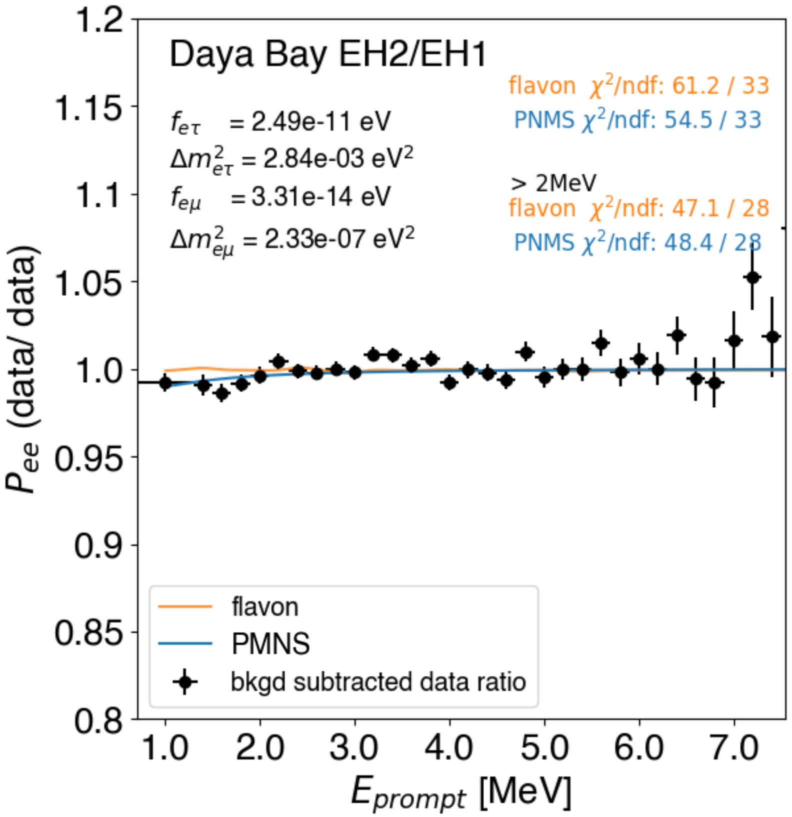
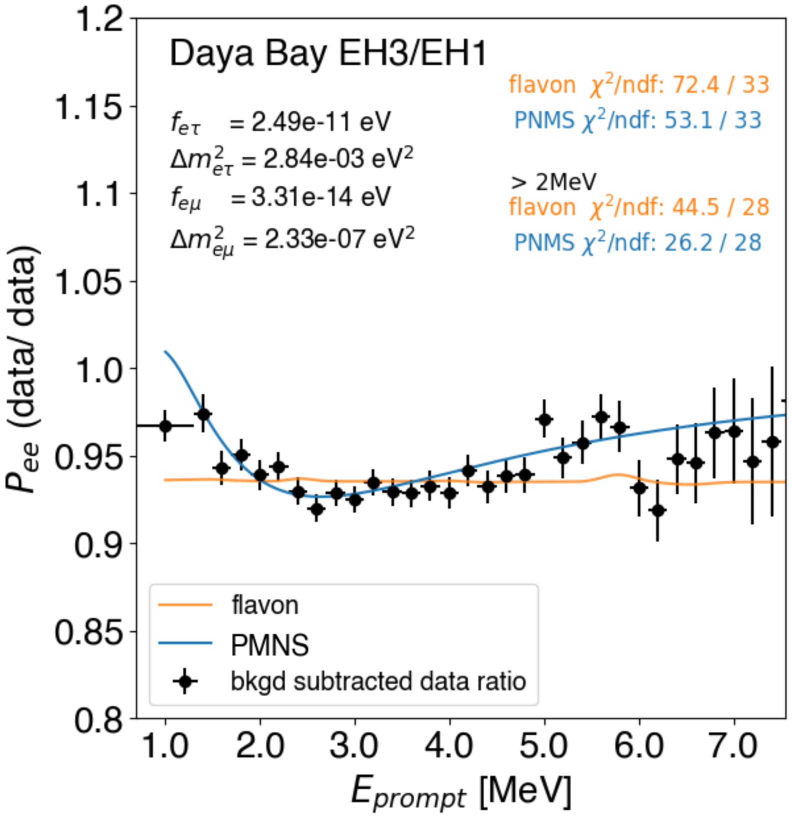
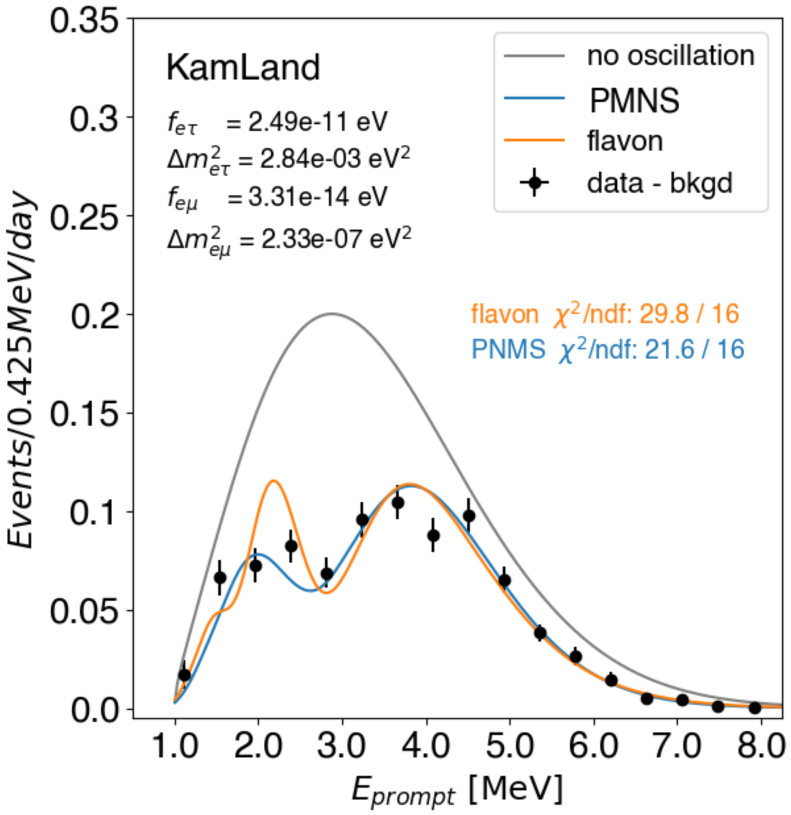






Reproduces expected features for flagship Daya Bay and KamLand experiments

New model of neutrino oscillations

Reproduces anomalous experimental results, but predicts CP Violation

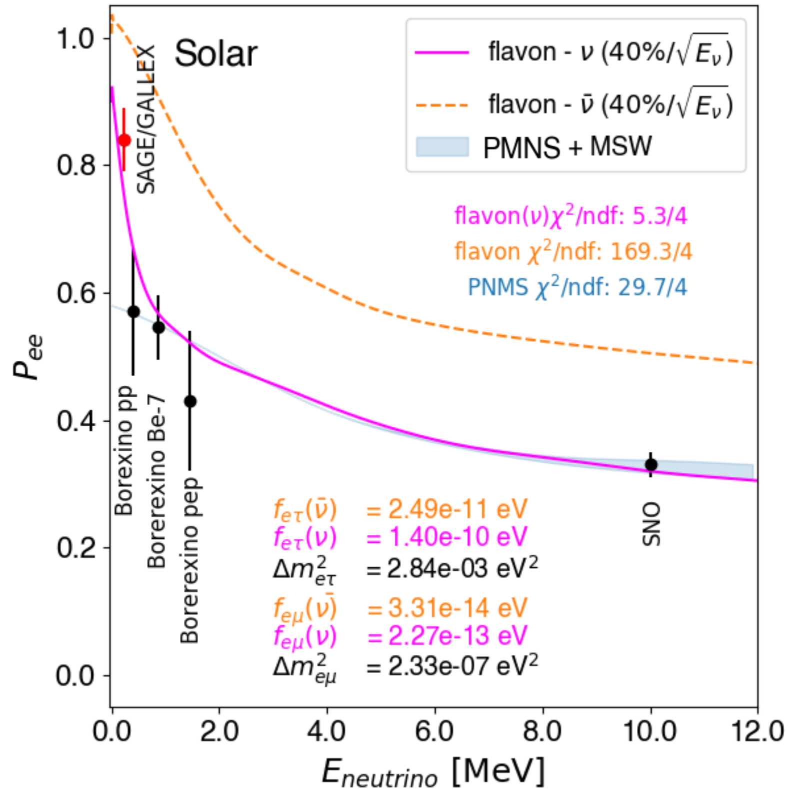
Perturbation

$f_{e\tau}$ = 2.49 x 10^{-11} eV
$f_{e\tau}$ = 1.40 x 10^{-10} eV

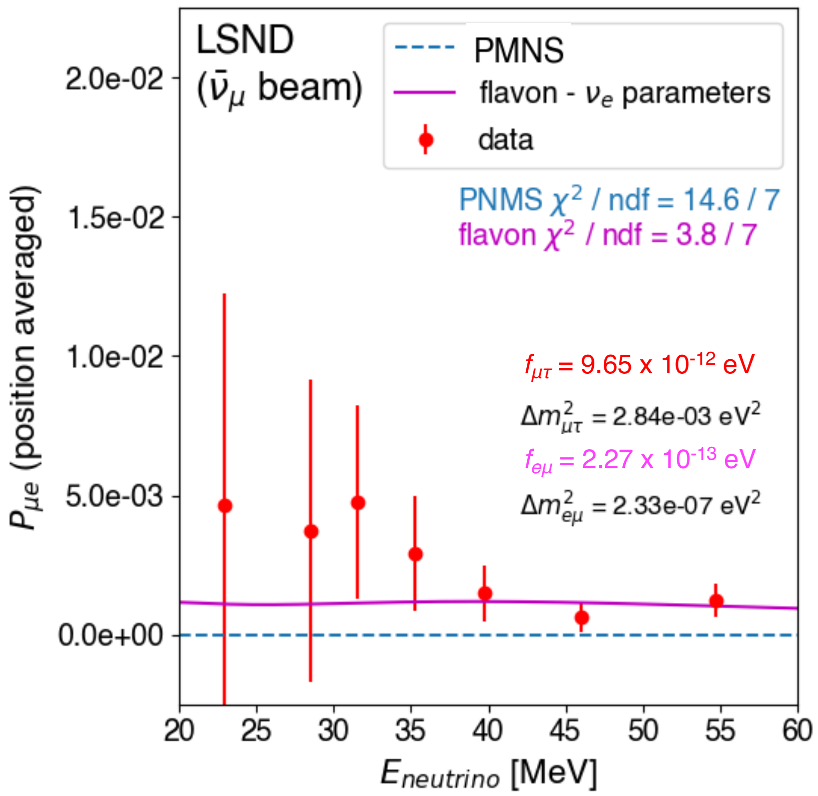
$f_{e\mu}$ = 3.31 x 10^{-14} eV
$f_{e\mu}$ = 2.27 x 10^{-13} eV

$f_{\mu\tau}$ = 9.65 x 10^{-12} eV

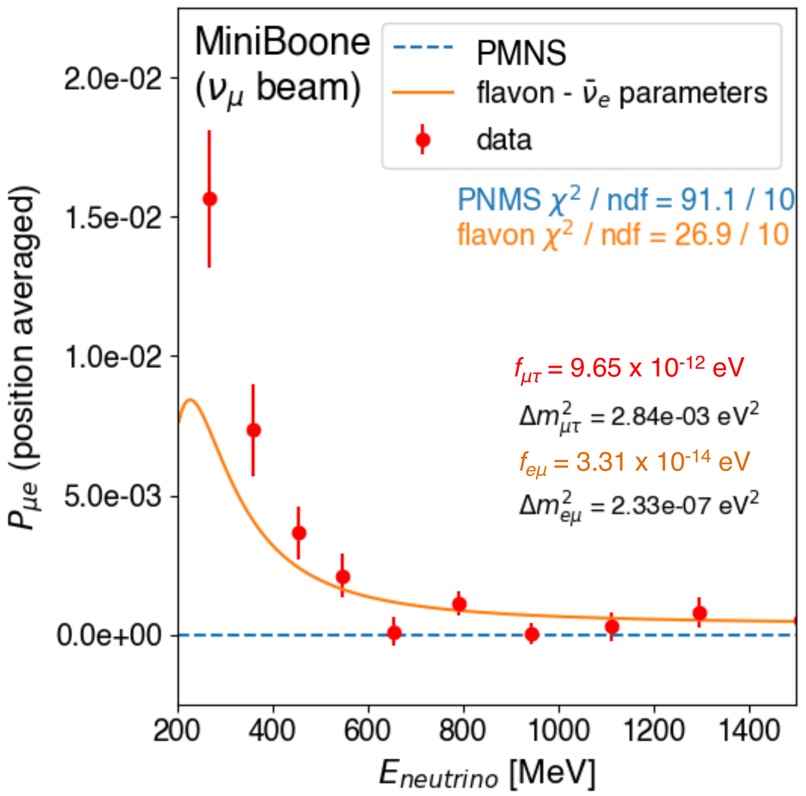
e-neutrinos and e-antineutrinos oscillate differently



e-neutrinos and µ-antineutrinos share parameters



µ-neutrinos and e-antineutrinos share parameters

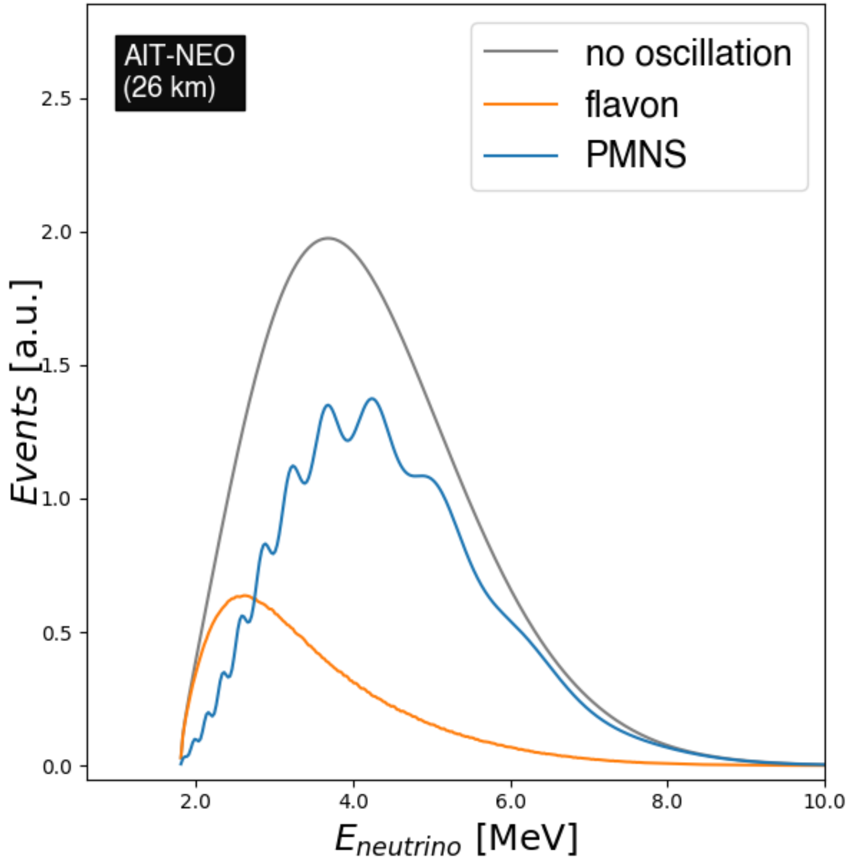


Reproduces MSW effect and reconciles with SAGE/GALLEX.
Provides adequate agreement to LSND/MiniBoone with reactor antineutrino and solar neutrino parameters.

Reactor antineutrinos at AIT-NEO

Flavon vs PMNS model

- The Advanced Instrumentation Testbed (AIT)* is a proposed neutrino physics experimentation site at the Boulby mine in the UK. The nearest reactor is 26 km away
- The first experiment at AIT, Neutrino Experiment One (NEO) will consist of a kiloton-scale detector with a Gd-H2O† or WbLS‡ target
- The rate and spectrum difference between the PMNS and flavon models is pronounced at this standoff, regardless of fill
- **Gd-H2O option:**
  - At 26 km standoff the flavon model predicts ~4 evts per month for a Gd-H2O target
  - while PMNS predicts ~25 evts per month
  - A Gd-H2O fill in NEO would rule out the PNMS model at 2.7 σ in 1 month.
  - A Gd-H2O fill in NEO would confirm the flavon model at 5σ in 6.5 months
- **WbLS option:**
  - Not yet studied in detail, but we qualitatively expect improved energy resolution and higher rates (due to lower energy threshold)



* AIT: SNOWMASS21-NF7_NF10-IF2_IF9_Adam_Bernstein-096.pdf
† Gd-H2O: SNOWMASS21-NF7_NF10-IF9_IF0_Adam_Bernstein-097.pdf
‡ WbLS: SNOWMASS21-NF7_NF10-IF9_IF0_Adam_Bernstein-098.pdf

Conclusion

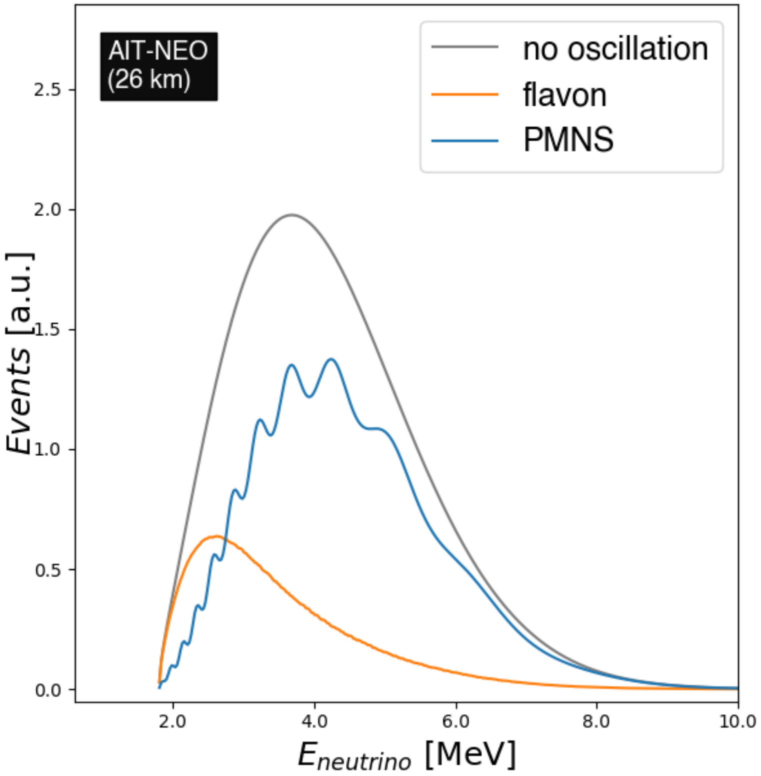
- I'm putting forward a new model for neutrino mixing – the flavon model

- The flavon model can be tested at two upcoming antineutrino reactor experiments (JUNO and AIT-NEO)

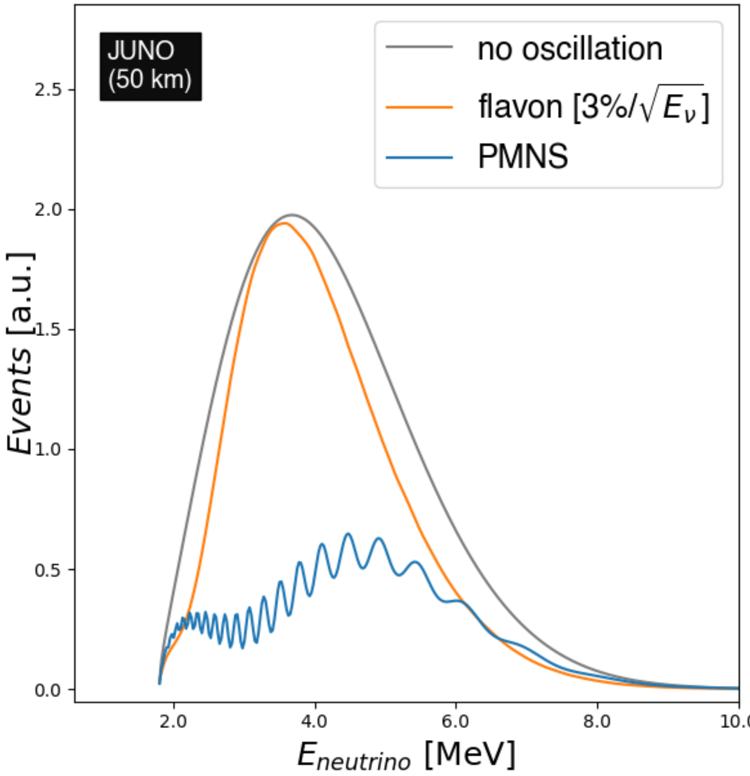
  — The AIT-NEO program in the Boulby mine is a new, highly leveraged resource for the HEP community to pursue technology and physics

  — JUNO is predicted to observe a rate and spectrum that will also refute or confirm the flavon model.

electron antineutrinos at local minima in mid-range



electron antineutrinos at local maxima in mid-range



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